LICHEN INVENTORY OF PINNACLES NATIONAL MONUMENT

FINAL REPORT

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A Project of the
National Park Service
Inventory and Monitoring Program
San Francisco Bay Area Network

Prepared by:

Shelly Benson, Rare Plant Biological Technician and Lichenologist
Point Reyes National Seashore

ABSTRACT

In 1997, when the San Francisco Bay Area Network parks began identifying knowledge gaps relating to park resources, lichens were recognized as an important and poorly understood ecosystem component of Pinnacles National Monument (PINN). In January 2003 funding was awarded through the Inventory and Monitoring (I&M) program to conduct a lichen inventory of PINN. The three week long field component of the inventory produced 419 collection specimens, comprising 202 species in total. One hundred and twenty-nine of these species were first recordings for the Monument and 21 are rare in California. The discovery of two new occurrences of the Globally Rare *Texosporium sancti-jacobi* (TESA), a critically rare lichen, brings the total for the park to six. Additionally, range extensions were documented for two of the existing TESA occurrences. The data mining effort uncovered 241 specimens collected from PINN, comprising a total of 164 species. Ninety-one of these species were not captured by the inventory. The current number of species on PINN's lichen species lists stands at 293 (up from 93 before this study). A complete reference collection was compiled for PINN and the remaining specimens are housed at the Santa Barbara Botanic Garden. In addition, a database was created for this project that meets I&M standards. As a result of this study, the inventory of lichens at PINN is estimated at 85% complete and the current knowledge about the extent of lichen resources in PINN has greatly increased. This study established the framework for inventorying lichens and provides a sound base on which a monitoring program can be built. Further inventory efforts should be conduced to investigate the 91 species not captured in the field component of this study. The presence of rare species (one of which is critically endangered) and the growing threat of air pollution extirpating pollution sensitive lichen species from the park make it critical that PINN begin to take steps to monitor and manage its lichen resources.

INTRODUCTION

A lichen is a composite organism containing a fungus (the mycobiont) and a green alga and/or a cyanobacterium (the photobiont). It is this unique relationship between the mycobiont and the photobiont that enables the lichen to be a ubiquitous organism, inhabiting most all ecosystems. Some lichens are primary colonizers, enduring harsh, inhospitable habitat conditions, while other lichen species colonize only the very oldest stands of old growth forest.

Lichens have no roots, they obtain all vital nutrients directly from the atmosphere. Lichens act like sponges, absorbing and retaining elements dissolved in atmospheric moisture. Some species are highly sensitive to air pollution and have no means to discriminate between vital elements and pollutants dissolved on atmospheric moisture. When pollution concentrations reach certain levels, pollution sensitive lichen species begin to die off and may disappear from the ecosystem. See Appendix A for a write up on 'what is a lichen' intended for PINN's natural resources web page.

California has a diverse lichen flora comprising approximately 1,000 species, representing nearly one third of all lichen species known in North America (Hale and Cole 1988). The variety of habitat types, combined with a Mediterranean climate, make the greater San Francisco Bay Area particularly rich in lichen diversity. Here, the geographic distribution of species from the cool, wet Pacific Northwest and coastal British Columbia overlap with species from the warmer coastal regions of southern California and Baja California.

Pinnacles National Monument (PINN) has an abundant and diverse lichen flora that is strikingly visible to the visitor and functionally important to the park's ecosystem. The rock outcrops for which PINN is named are a key habitat for a great diversity of the park's lichen flora. Many of the rock surfaces appear to be painted in shades of red, orange, yellow, green, and brown due to prolific lichen growth. The unique soil lichen communities found on open talus slopes in the chaparral vegetation community are crucial in stabilizing soil. In the oak woodlands, the trunks and branches of oak are typically encrusted with lichen, covering nearly every available surface. Long and intricately branched, pendulous lichens drape from oak branches. This dense lichen growth provides food and shelter for a variety of vertebrate and invertebrate species (i.e. deer, insects, and mites). The long pendulous lichens are commonly used as nesting material by birds and rodents. Lichens are important contributors to ecosystem processes by aiding in nutrient cycling and retaining humidity in forest stands (Gerson and Seaward 1977, Pike 1978, Rhodes 1995). In addition, scientists use lichens as indicators of air pollution, forest health, and forest age (Goward 1994, Loppi 1996, McCune 2000).

In 1983 Desjardin discovered a population of the rare lichen *Texosporium sancti-jacobi* (TESA) at PINN (Bratt 2002). TESA is a small inconspicuous crust lichen found on soil and decaying organic matter. The thallus (lichen body) ranges in color from whitish to gray and has distinctive cup-shaped apothecia (0.5-1.5 mm diameter) with a white to yellow rim. The cup is so full with olive-green to blackish spores that they protrude slightly above the rim of the cup. TESA is the only species in the genus. The International Committee for the Conservation of Lichens has ranked TESA as critically endangered on the Global Red List of Lichens (Thor 1996). In Califronia, it is listed as a "Species of Special Concern" (California Department of Fish and Game 2002) and the California Lichen Society (CALS) gave TESA a R-E-D code of 3-3-2 (occurrences infrequent and consisting of few individuals, endangered throughout its range, rare outside CA) (Magney 1999). It known only from a few disjunct locations worldwide, all in western USA (WA: Benton and Klickitat counties; ID: south of Boise; OR: north of Bend; CA: PINN, Aliso Canyon/Cuyama Valley in Santa Barbara County, San Clemente Island, Santa Catalina Island, Western Riverside County, and San Diego County) (Bratt 2002, McCune and Rosentreter 1992, Ponzetti 1999).

TESA is rare both on a regional and local scale. Although the geographic range of TESA is wide the number of occurrences are few and widely scattered. Also, populations are small and restricted to specific microhabitats. TESA requires arid-semiarid climate; nearly flat ground; noncalcareous, nonsaline soils; little evidence of recent disturbance; hardened soil; and sparse vegetation cover. On these sites TESA is further restricted to microsites containing small bits of decaying organic matter. For example, TEXO is commonly found on decaying rabbit pellets, dead stems of selaginella, and stubble from dead tufts of bunchgrass, and on other soil lichens.

In 1997, when the San Francisco Bay Network (SFBN) parks began identifying knowledge gaps relating to park resources, lichens were recognized as an important and poorly understood ecosystem component of PINN. Prior to this study, a comprehensive lichen species list for PINN did not exist despite the diverse lichen flora (including one critically endangered species), and the threat of air pollution to sensitive lichen species. Several lichen studies have been conducted at PINN (Smith 1990, McCune & Rosentreter 1992, Bratt 2002, S. Jovan 2002 unpublished), each producing a species list, however these lists were incomplete and the need for a comprehensive lichen inventory still existed.

In January 2003, funding was awarded from the Inventory and Monitoring (I&M) program for a lichen inventory of PINN. The objectives of the study were to:
1. create a comprehensive species list of lichens,
2. compile a complete reference collection of the species found and deposit it in the PINN museum,
3. collect preliminary distribution and local rarity information for each species,
4. identify lichen species that are suitable for use in long-term monitoring programs, and
5. obtain GPS data for new occurrences of rare lichens found through inventory efforts.

METHODS

Sampling design

This study used the "expert approach," which employs the concept of fine focused searches, looking in areas where high diversity is expected. This method was selected based on its ability to maximize the detection of species diversity while minimizing the number of sample plots needed. This design is flexible and allows for a reduction in sample size without seriously compromising its ability to capture species diversity, unlike a randomized design.

The expert approach has five basic criteria. First, each major vegetation community type (here after referred to as vegetation alliance) must be represented in the study. Collection sites should be located throughout the entire range of the vegetation alliance with one or more sites in each of five regions--northern, southern, eastern, western, and central. Second, the collection effort will focus on microhabitats associated with lichen diversity (i.e. rock outcrops, moist soils, and standing dead trees). Third, at the end of the collection event, a minimum area of one hectare must be searched. Fourth, a voucher specimen from each different lichen species observed will be collected at each site. Finally, a trained lichenologist must conduct the surveys to ensure the highest quality of species detection (many lichen species look similar to an untrained observer) and to identify habitats that are diversity hot spots.

One weakness of this approach is that it lacks the statistical power needed to extrapolate the results to a broader, park-wide scale. A randomized design using fixed area plots will provide greater statistical power, however the associated costs are an increase in number of sampling plots and field time required, and a reduction in number of species captured. Despite this limitation of the expert approach, general statements about lichen distribution and local rarity can be made based on frequency data. The strength of the statements will increase with the number of sites sampled.

The park vegetation map was used to identify the major vegetation alliances in PINN. A reconnaissance trip was made to the park in January 2003 to assess lichen abundance and diversity in the vegetation alliances and identify microhabitats associated with diversity hot spots. This information aided in placement of collection sites. Fire GIS data was used to ensure sites were not placed in areas that had burned within the past 30 years. It is known that fire kills lichens and they are relatively slow to re-colonize an area (McCune and Rosentreter 1992). Therefore, burned areas were expected to have less biomass and diversity of lichens than unburned areas. Preference was given to suitable sites located close to a road or trail for quick and easy access. Eight vegetation alliances were identified for sampling (Table 1) and eleven collection sites were established (Figure 1). The selaginella alliance, found on open scree slopes and ridges, is not recognized on the vegetation map. This habitat contains a high diversity of soil lichens and for the purpose of this project was treated as a unique alliance. The target sample size of four to five collection sites per vegetation alliance was not achieved due to limited time and resources. The ramifications of the small sample size are addressed in the discussion section.

Table 1. Number of lichen collection sites established in each vegetation alliance for the 2003 PINN lichen inventory.

Vegetation alliance	4-letter code	Number of sites established
California buckeye	CABU	1
Chaparral	CHAP	1
Grassland	GRAS	1
Holly-leafed cherry	HOCH	1
Oak woodland	OAWO	1
Riparian woodland	RIWO	1
Rock	ROCK	3
Selaginella	SELA	2
Total	8	11

A field survey form was filled out at beginning of the survey which documented site location and habitat description information (Appendix B). A Garmin III GPS unit was used to record the UTM coordinates (reported in NAD 83) of the approximate center of the plot. Additional UTM coordinates were taken at the location of any rare species or species of interest. The start and stop times of the survey were recorded on the field survey form to calculate the average time required to conduct this type of survey. The survey was considered complete after the minimum area (1 ha) had been thoroughly searched and at least 20-30 minuets had passed without documenting any additional species.

A voucher specimen was collected for each different lichen species found at the site. Enough material was collected to fill the space on a 3 x 5 inch card. This amount of material is adequate for identifying the specimen and having enough left over to serve as a reference specimen. A knife was used to remove lichens from wood and soil, and a hammer and chisel were used to remove lichens on rock. Rock pieces containing lichen material were wrapped in paper towel for transport out of the field to prevent from rubbing and damaging the specimens. Each specimen was placed in a paper collection envelope and labeled with appropriate tracking and identification information (Appendix C). To save time, most of the labeling information can be entered in the lab. In this case, it is important that all the collections for a site are kept together in a paper bag labeled with the site information.

Processing specimens

In the lab, specimens were mounted for herbarium storage. Crust-like specimens on rock and wood/bark were glued (using acid free herbarium glue) directly to 3 x 5 inch card of acid free herbarium mounting paper. This protects the specimens by preventing them from shifting around in the envelope. Additionally, a layer of herbarium quality white cotton padding was placed over powdery specimens. Before mounting soil lichens, they were first infused with a 1:1 solution of herbarium glue and water to prevent the specimen from breaking apart. First, the loose soil on the underside of the specimen was sprayed with a fine mist of water. Once the water soaked in, a coat of the glue solution was brushed over the wetted underside of the specimen. Care was taken not to allow the glue solution to seep through and coat the lichen surface, as this interferes with the identification process. Once the first coat of glue solution soaked in, a second coat was applied. When the underside of the lichen had set up, it was then glued to a 3 x 5 inch card of acid free herbarium mounting paper. Foliose species were not glued to a 3 x 5 card because the identification process required inspection of both the upper and lower surface of the lichen. Fragile foliose specimens were placed between a folded piece of cotton padding for extra protection inside the envelope. All specimens were placed in herbarium quality acid free envelopes with label information affixed to the front flap. The specimens were placed in the freezer for four days, to kill any insects, before being stored in the herbarium.

Specimen identification

A portion of the lichens were identified at biweekly lichen identification sessions offered by the California Lichen Society (CALS). The remainder of the specimens were sent out to professional lichenologists for identification. See Appendix D for contractor contact information and contract details.

Database/data analysis

A Microsoft Access database was built for this project. The database design meets the standards set by the I&M program. This database will serve as a template for other lichen inventory and monitoring projects and can easily accommodate lichen data collected from other SFBN parks. See Appendix E for the location of the database on the PORE network server, along with a complete list of pathways to all other electronic products produced in association with this project.

RESULTS

2003 inventory

The three week long field component of the inventory produced 419 collection specimens, comprising 202 species in total (Appendix F). One hundred and twenty-nine of these species were first recordings for the Monument. Twenty-one of these species are ranked as rare in California by CALS (Appendix G). The data mining effort uncovered 241 specimens collected from PINN, comprising a total of 164 species. Ninety-one of these species were not captured in the field inventory. The current number of lichen species known from PINN's stands at 293 species, up from 93 before this study.

Texosporium sancti-jacobi

Two new occurrences of TESA were discovered as part of the inventory. This brings the current total of TESA occurrences in PINN to six. Range extensions were documented for two known TESA occurrences.

Due to time constraints, surveys were not conducted to determine the size of the occurrences or the number of individuals/colonies. Voucher specimens were not collected from some sites because there were too few individuals. At one site, close-up photographs were taken by Richard Doell of the single colony found on a large, downed tree. Three of the new sightings document TESA growing on wood, dead selaginella twigs, soil, and other soil lichens for the first time at PINN. All previous occurrences documented TESA on old rabbit pellets.

History of lichen studies at PINN/Data mining

There have been relatively few lichen studies at PINN considering its rich lichen diversity and long history as a protected landscape. It was not until 1984 when C. W. Smith of the University of Hawaii at Manoa conducted the first formal lichen study of PINN. The objective of the study was to inventory the lichens of the monument with the intent to asses the local air quality condition using lichens as bioindicators and to establish long-term air pollution biomonitoring sites. Smith focused on corticolous lichens (those growing on bark) because of their sensitivity to air pollution. He reported 93 lichen species (Appendix F) and concluded the air quality at PINN was excellent based on the condition of the lichens; abundant, reproductive, and no signs of thallus (lichen body) bleaching—a diagnostic symptom of pollution damage (Smith, 1990). He also provided recommendations for establishing a cost-effective biomonitoring program at PINN. Refer to his final report for a description of the areas he surveyed. Smith reported that he returned the voucher specimens collected during the project to the park for permanent storage (personal communication).

In 1991 B. McCune and R. Rosentreter conducted a study of the Globally Rare lichen TESA (McCune and Rosentreter 1992). The objectives of the study were to gather information on habitat requirements at known locations for TESA and attempt to locate additional populations. At PINN, they visited the one known location of TESA at Chalone Creek, discovered by Desjardin in 1983 (Bratt 2002) and discovered a second occurrence on the High Peaks Trail near the junction with Condor Trail. They reported 25 associated lichen species at these two sites (Appendix F). McCune collected thirty-eight lichen voucher specimens from PINN and they are housed at the Oregon State College herbarium, part in the regular collection and part in B. McCune's research collections.

In May 2002, C. Bratt conducted a second survey for TESA in PINN with T. Leatherman. They reported that the flooding in 1998 destroyed the original population TESA along Chalone Creek. Three new TESA sites were found in the Chalone Creek area and the High Peaks Trail/Condor Trail site was relocated and TESA was found.

S. Jovan established a permanent lichen monitoring plot at PINN in July 2002 as part of a project titled "Forest Health Monitoring Study of Lichen Community Gradients in California: using lichen communities as bioindicators of air quality and climate" (see permit, possible publication). The purpose of the study was to develop models that use epiphytic macrolichen community composition to indicate and predict air quality in CA. She collected 25 specimens comprising 19 species (Appendix F). These specimens reside at the Oregon State University herbarium.

Smith conducted a search for historical lichen collections from PINN. The following excerpts were taken from his final report titled "Lichen Air Pollution Biomonitoring Study of Pinnacles National Monument" (in PINN lichen paper file):

> "The following herbaria were visited: San Francisco State University, University of California at Berkeley, Los Angeles Museum, and the Smithsonian Institute. Enquirys were also made at the University of Colorado. The only herbaria that had collections from PINN were San Francisco State and the Smithsonian Institute."
>
> "I have not been able to located any collections of lichens in PINN prior to 1963. In that year, Dr. H. D. Thiers, San Francisco State University visited the Monument and made a number of collections then and on subsequent visits. In later years, several of his students also visited the area: J. Ammirati in 1966, D. E. Desjardin 1982, 1983, S. Hammer 1986, A. S. Methven 1982, S. Strick 1975, and B. Thiers 1977. Dr. Mason Hale, Smithsonian Institute, has visited the Monument on several occasions making collections in 1965, 1978, and 1985."

The San Francisco State herbarium is currently upgrading its catalogue system to a database. Dr. Dennis Desjardin manages the herbarium and should be contacted in the future to gain a list of PINN voucher specimens housed at the facility. Refer to Appendix D for contact information. The Smithsonian Institute was not contacted as part of this study, however it would be beneficial to gain a list of PINN voucher specimens housed at the facility.

As part of this study, the online databases for the herbaria at Arizona State University (ASU) and the Santa Barbara Botanic Garden (SBBG) were searched for lichen collections from PINN. The ASU herbarium contains 98 records from PINN, comprising 77 species. The search of the SBBG revealed 70 records from PINN, comprising 30 species (Appendix F).

DISCUSSION

2003 inventory

Before this study, resource managers at PINN knew of only 93 lichen species reported for the park. Adding 200 species to PINN's lichen list attests to the success and significance of this inventory. The expert approach was an effective method for capturing species diversity. The inventory of lichens at PINN is estimated at 80% complete at best considering the low number of sample sites and that 91 species previously documented in PINN were not recovered in the field inventory, nearly half of the total number of species captured (202 species). It is expected that adding more sites to each vegetation alliance will uncover additional lichen species, especially if the four minor alliances not represented (digger pine woodland, herbaceous, coastal sage scrub, and barren) are investigated. These were abandoned due to their small aerial extent and time constraints on the project.

The target sample size of four to five sites per vegetation alliance was not achieved due to limited time and resources. Only the rock and selaginella alliances had multiple sampling sites, 3 and 2 sites respectively. The average time required for one person to conduct a survey was 3 hours. Adding a trained field assistant could reduce this time. The exception to this is conducting surveys in the rock alliance. At all 3 rock sites a trained assistant was present and the average time for 2 people to complete a survey was 3 hours and 45 minutes. These sites were particularly time-consuming due to the difficulty of collecting lichen specimens from rock. For each desired species a fare bit of searching was required to find it in a location where a flake of rock could be chipped away using a hammer and chisel. This task was particularly challenging at PINN because most of the rock is rhyolite breccia, which shatters easily, often destroying the lichen specimen.

The project was funded for 22 weeks and was over budget by 4 weeks. I contributed volunteer hours to make up for the shortfall in funds. Two tasks took more time than expected, processing specimens and building a database that meets I&M standards. The funds dedicated toward identification contracts were essential.

Table 3. Break-down of time required for project tasks, 2003 PINN lichen inventory

Tasks	Number of weeks
Develop methodologies and select field sites	3
Reconnaissance trip to PINN	1
Logistics for field work and organize field gear	1
Field work	3
Process specimens	4
Identify specimens	3
Prepare lichen identification contracts	2
Create database, enter data, data analysis	4
Data mining	1
Prepare report	3
Compile reference collections and prepare for shipment to herbaria.	1
Total	26

The ability to make statements about lichen distribution and local rarity is severely limited by the small sample size. Additionally, comparisons among alliances is further complicated by the time saving practice of not collecting species that were known to have been collected at other sites. This practice was used at the following sites: ROCK-02, ROCK-03, RIWO-01, HOCH-01, and GRAS-01. Therefore, no generalizations about lichen distribution or local rarity were made. However, establishing additional sampling sites will provide the supplemental data needed to address these shortfalls and begin to validate trends in lichen frequency and distribution data. Suggested locations for additional sites are plotted on hard copy maps included in the 'site maps' folder (these maps do not exist electronically). Appendix H shows the lichen species collected at each site.

Texosporium sancti-jacobi

The TESA population found in the oak woodland alliance at one site is very interesting because of its habitat. This site is dominated by blue oak (*Quercus douglasii*) with an understory of annual grasses and forbs comprising nearly 100% cover. It is located on a moderate slope with eastern exposure. No other TESA population has been reported from similar habitat conditions. This is the first record of TESA occurring on a large downed log, still in the early stages of decay (bark missing but outer wood still hard). New populations of TESA are being discovered with increasing regularity, this due to increased scrutiny of suitable habitats by lichenologists. Each additional find increases our understanding of this rare species. However, our knowledge of a species is often limited by our preconceived perception of where we expect to find it. This recent find at PINN is significant because it broadens the range of potential habitat types where TESA may be found.

Conservation

The California Lichen Society is developing a list of rare California lichens modeled after the California Native Plant Society (CNPS) list of rare California plants, an important tool used by federal, state and local agencies in managing natural resources. The list of rare lichens is a work in progress since information on the abundance and distribution of many potentially rare lichens is lacking. The results from the 2003 PINN lichen inventory will be a valuable contribution to the deliberations for the final list of rare California lichens.

Monitoring

Lichens are well known as indicators of change and are widely used in monitoring programs. Specific groups of lichen indicate specific types of change. Therefore, selecting lichen species for use in a monitoring program is based on the monitoring goal. The two main types of monitoring that use lichens as biological indicators are ecosystem change and air quality. Rare lichens are good indicators of ecosystem change (i.e. climate change). The twenty-one rare species documented in this study all have potential as biological indicators. Each species should be ranked for feasibility of monitoring. The biggest factor to consider in the ranking process is detectability of the lichen. Species should be medium-large in size to be seen relatively easily and distinctive so that they can be positively identified in the field. An effective monitoring program depends on complete and accurate information about the full extent of the species within the park. Therefore, further inventory efforts will be required.

Lichens can be used to monitor air quality in two ways. First, lichen community composition can be assessed, noting specifically if pollution sensitive lichen species are present or absent. Lichen species react differently to pollutants, that is some species thrive in high nitrogen environments while other species are extremely sensitive to nitrogen and disappear from the ecosystem when concentrations are high. The assemblage of lichen species at a site provide specific information about local air quality. Second, lichens can be collected and analyzed for chemical composition. Lichens are passive collection systems, absorbing atmospheric inputs. Chemical analysis of lichen tissue is a direct measure of air quality/pollution concentrations. For more details on these monitoring techniques refer to Blett et al. (2003) report titled "Air Pollution-Related Lichen Monitoring in National Parks, Forests, and Refuges: Guidelines for Studies Intended for Regulatory and Management Purposes."

PINN hosts an extremely rich diversity of lichens, undoubtedly many of which are sensitive to pollution. Lichens are particularly sensitive to nitrogen and sulfur. Both of these pollutants are on the rise in the northern California-San Francisco Bay area region due to increasing demand for agricultural outputs and increasing population growth (more motor vehicle use) (personal communication with Sarah Jovan, Oregon State University and Linda Geiser, Pacific Northwest Region Air Resource Management USDA Forest Service). The presence of rare species (one of which is critically endangered) and the immediate and significant threat of air pollution extirpating taxa from the park make it critical that PINN begin to take steps to monitor and manage lichens.

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Arizona State University online lichen databse: http://ces.asu.edu/ASULichens/

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APPENDIX D

Contact information

Name	Address
Shelly Benson	Research Staff, Dept. of Biology, Sonoma State University,
Dr. Dennis Desjardin	Manager of H. D. Thiers Herbarium San Francisco State University Hensill 429 415-338-2439 ded@sfsu.edu
Bruce McCune	Department of Botany and Plant Pathology Oregon State University Corvallis, OR 541-737-1741 mccuneb@bcc.orst.edu
Richard Doell	Photographer, California Lichen Society 1200 Brickyard Way, #302 Point Richmond, CA 94801 rdoell@sbcglobal.net
Sarah Jovan	Department of Botany and Plant Pathology Oregon State University 2082 Cordley Hall Corvallis, OR 541-737-2675 jovans@bcc.orst.edu
Bob Muller,	Director Santa Barbara Botanic Garden 1212 Mission Canyon Road Santa Barbara, CA 93105 805-682-4726 x 150 rmuller@sbbg.org
Clifford W. Smith	Cliffard7@aol.com (yes, his email is spelled correctly with an 'a')

Contractor	Contact Information	Number of Specimens	Rate	Contract Amount
Judy Robertson	362 Scenic Ave, Santa Rosa, CA 95407 707-584-8099 JKSRR@aol.com	108	$25/hr	$600
Tom Carlberg	1959 Peninsula Drive, Arcata, CA 95521 707-442-0530 tcarlberg7@yahoo.com	27	$65/hr	$900
Shirley Tucker	Department of Biology-EEMB, University of CA—Santa Barbara, Santa Barbara, CA 93106-9610 805-898-0908 tucker@lifesci.ucsb.edu	35	$100/hr	$1,000
Cherie Bratt	Santa Barbara Botanic Garden, 1212 Mission Canyon Rd., Santa Barbara, CA 93105 805-682-4726 x152 cbratt@sbbg.org	161	$25/hr	$2,500

APPENDIX G

Rare lichen species at PINN

Listing of rare species based on the CALS list of Rare California Lichens (check for updates on the CALS web page: http://ucjeps.berkeley.edu/rlmoe/cals.html).

Species
Acarospora obpallens (Nyl.) Zahlbr
Acarospora obpallens (Nyl.) Zahlbr.
Aspicilia californica Rosentreter
Caloplaca demissa (Körber) Arup & Grube
Cladonia asahinae J.W.Thoms.
Collema cf.polycarpon Hoffm.
Dimelaena thysanota (Tuck.) Hale & Culb.
Diploschistes diacapsis (Ach.) Lumbsch
Fuscopannaria californica (Tuck.) P.M.Jörg.
Fuscopannaria coralloidea P.M. Jørg.
Fuscopannaria pacifica P.M.Jorg.
Lecanora hybocarpa (Tuck.) Brodo
Lecidea cf. austrocalifornica Zahlbr.
Lecidea cf.austrocalifornica Zahlbr.
Mycobilimbia beringeriana (A. Massal.) Hafellner & V.Wirth
Physconia californica Essl.
Placynthiella uliginosa (Schrader) Coppins & P. James
Protoparmelia badia (Hoffm.) Hafellner
Rhizocarpon distinctum Th. Fr.
Rinodina conradii Körb.
Texosporium sancti-jacobi (Tuck.) Nadv.